Numerical modeling of hyperelastic-plastic flows in cylindrical geometry by means of a colocated Lagrangian hydrodynamics method

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ABSTRACT

The recent development of Finite Volume (FV) discretizations for Lagrangian solid dynamics seems to be a promising alternative to the traditional Finite Element approaches, refer to [1]. The Colocated Lagrangian Hydrodynamics (CLH) method is a moving mesh Finite Volume discretization, initially developped for gas dynamics, and recently extended [2] to the so-called Wilkins hypoelastic model [4]. This model arises two main difficulties [3]. First, the definition of objective stress rates is somewhat arbitrary and not unique. Second, hypoelastic based models are characterized by a non-zero rate of entropy in elastic regime. To cure the aforementioned flaws of the hypoelastic approach in the context of fast solid dynamics, we present a CLH numerical method that solves the conservation laws of continuum mechanics (mass, momentum and total energy) for isotropic materials characterized by an hyperelastic constitutive law in the elastic regime. The material constitutive law is derived according to the principle of material frame-indifference (objectivity) and consistently with the second law of thermodynamics. The plastic regime is characterized by a von Mises type yield function. The elastic-plastic strain decomposition relies on the multiplicative decomposition of the deformation gradient tensor. An associative plastic flow rule is written by means of a specific objective plastic strain rate. The plasticity model is completed by an isotropic hardening law characterizing the evolution of the yield limit. The foregoing conservation laws are solved in two-dimensional cylindrical geometry by means of a Control Volume CLH discretization. The robustness and the accuracy of this numerical method shall be demonstrated by means of challenging test problems.

References

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